CANOPY ARTHROPOD DIVERSITY OF NEW CALEDONIAN FORESTS SAMPLED BY FOGGING : PRELIMINARY RESULTS

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Faunal composition and community stucture of canopy arthropods was analyzed from insecticidal fogging samples in 3 types of New Caledonian forests: dense evergreen forest on ultramafic alluvium (Rivière Bleue), sclerophyllous forest on limestone and conglomerate (Pindaï) and sclerophyllous forest on schists (Païta).
Mean arthropod density in both sclerophyllous forest was significantly higher than in the dense evergreen forest. Without considering the introduced ant *Wasmannia auropunctata* which occurs in both sclerophyllous forests, the prevalent orders are Collembola in evergreen forest, Psocoptera in both sclerophyllous forests, and Diptera (Nematocera) in all 3 forests. The 3 forests are characterized by the prevalence of non-insect predators (mostly Araneae) and epiphyte grazers. *W. auropunctata* is the prevalent group in the sclerophyllous forest of Païta but not in Pindaï.
In spite of its ecological imprecision, the fogging method is still a faster and easier way to obtain information on global biodiversity which is most urgently needed for monitoring ecologically sensitive areas in tropical forests.☐*Insecticide fogging, New Caledonia, forests, canopy, arthropods.*

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Arthropod communities in rainforest canopies have attracted increasing interest during the last 20 years, in relation to the development of fogging techniques first introduced by Martin (1966; Roberts, 1973; Erwin, 1982; Stork, 1988). In particular, the use of these techniques by Erwin (1982) provided the first projection of total richness of the biosphere and initiated further works on this subject (Stork, 1988; May, 1990).

New Caledonia has been recognized as one of the 'hot spots' of biodiversity (Myers, 1988). In the last eight years, many taxonomic descriptions have significantly increased knowledge of its fauna (e.g., Tillier, 1988; Chazeau & Tillier, 1991; Matile, Najt & Tillier, 1993). However, very little is still known of the arthropod fauna of the canopy.

It seems now necessary to go beyond classical taxonomical descriptions in order to allow comparisons of local diversities and raise local interest for conservation of the most representative threatened natural biotas. To study diversity patterns, sampling should account for spatial and seasonal variations of taxonomical groups. For this purpose, we have implemented a fogging method adapted to local conditions. Preliminary results on 3 types of New Caledonian forests are discussed here.

METHODS

SAMPLING SITES

Three sampling sites were selected in two forest types. Two sites are relictual sclerophyllous forests, on limestones and conglomerates in Pindaï (North Province. alt. 30m) and on schists in Mt. Nondoué, Païta (South Province, alt. 110m). The third site is located in dense evergreen forest on ultramafic alluvium in Rivière Bleue Provincial Park (South Province, alt. 160 m). The Païta and Pindaï sites were included formerly in a botanical survey of the New Caledonian sclerophyllous forests (Jaffré et al., 1993). The Rivière Bleue site was described by Bonnet de Larbogne et al. (1991) and a comprehensive study of its vegetation was given by Jaffré & Veillon (1991). Species richnesses of forest phanerogames amount to 102, 108 and 219 in Païta, Pindaï and Rivière Bleue sites, respectively.

In each site, we used 40 x 1^2 collectors grouped in 4 neighbouring plots of 10 collectors that maximised stability of data and allowed us to analyse spatial heterogeneity within plots and between plots. Spatial analysis will not be discussed here. One plot covers an area of 30-40m^2 and one site corresponds to 350-400m^2. Each site was

Table 1. Climate and weather conditions during fogging at each site.

Average conditions (nearest location)	Païta	Népoui	Ouénarou
Temperature: 1961-90	23°C	23°C	21.5°C
Annual rainfall: 1971-90	1191mm	913mm	2518 mm
Conditions during fogging (at the sites)	Païta	Pindaï	Rivière Bleue
Temperature	16°C	15°C	11°C
R.H.	84%	92%	94%

sampled 4 times a year in order to cover seasonal variations. We here analyse results from the first sampling made during the dry season (30 June/ 16 July 1992).

Fogging & Collecting

A portable fogging machine (Dyna-fog Golden Eagle Backpack 2980) was used to generate a fast killing fog from a mixture of Cyfluthrin, water and polyhydric alcohols (400cc of Solfac EW 050 in 4 litres of Maxifog solvent). The 4 plots of each site were sampled consecutively early in the morning, 4 minutes each, within a time c.20-30 minutes in each site. The moderate height of the canopy in Rivière Bleue and Païta (15-25m) and in Pindaï (8-12m) allowed operation from ground level. The machine manipulated from the ground, propelled the fog upwards, but successful sampling required strict weather conditions, without any wind nor rain (see Table 1). White heavy plastic collecting sheets were hung with rubber bands on 1m x 1m square iron frames raised 0.5 or 0.8m above the ground on removable sticks, which allowed attainment of a horizontal level for the trays even on steep slopes. All arthropods which had dropped on sheets after two hours were collected by washing with water and wetting agent. A two hour drop-time was recommended as optimal by Erwin (1983) and Stork (1987). The liquid was filtered then through a double screen (0.6mm and 0.3mm), and the specimens collected were stored in 95% alcohol. Washing and filtering were carried out in the field.

The specimens were sorted to order level for all arthropod taxa and at family level for Araneae, Hymenoptera, Hemiptera, Coleoptera and Diptera (Appendix). Arthropod taxa were assigned to guilds as defined by Stork (1987), Moran & Southwood (1982) and Basset (1991).

Statistical analysis has been performed using the SAS package. Non-parametric tests (Kruskal-Wallis test and Wilcoxon 2-sample test) were used to compare the data which were still not normally distributed after their transformation. The dispersal index $ß=s^2/m$ (where s^2 is the variance and m is the mean; Cancela da Fonseca, 1966) was calculated for each site and for each family sampled. Aggregative distribution ($ß>1$) was tested by T-test.

Table 2 a, b. Comparison of mean abundance of total arthropods (Total) including and excluding *W. auropunctata* (without *W.*).
a (upper). Comparison for 3 sites by Kruskal-Wallis Test (Chi-Square (χ^2) Approximation, Df=2).
b (lower). Comparison for 2 sclerophyllous forests by Wilcoxon 2-Sample Test (Normal Approximation).

Variable	F Value	P>F	χ^2	$P>\chi^2$
Total	19.513	0.0001	53.919	0.0001
Without *W.*	12.647	0.0001	16.985	0.0002
Variable	F Value	P>F	Z	P>|Z|
Total	13.149	0.0005	-3.31978	0.0009
Without *W.*	0.046	0.8307	-0.13953	0.8890

RESULTS

Arthropod Density & Local Distribution

The densities of arthropods was 1374, 545 and 281 ind./m^2 in Païta, Pindaï and Rivière Bleue, respectively.

The forests in Païta and Pindaï have been invaded by the neotropical ant *Wasmannia auropunctata* (Roger) which constituted 65% and 15% of the specimens collected in Païta and Pindaï, respectively. After removing the invader from the samples, the mean abundances of arthropods in both sclerophyllous forests were found quite similar (Table 2), while a much lower abundance was still noticeable in Rivière Bleue. Subsequent analysis of abundance patterns exclude *W. auropunctata*.

Dispersal indices tested by T-tests show that 49% and 36% of the families in the sclerophyllous forests of Pindaï and in Païta, respectively, are distributed in aggregats; whereas only 18% of the families exhibit such a distribution in the rainforest of Rivière Bleue.

Abundance Patterns

We found 54974, 21815 and 11260 specimens in Païta, Pindaï and Rivière Bleue, respectively. At order level, the three sites differed by their abundance patterns, but the 2 sclerophyllous forests were more similar to each other than to the rainforest (Table 3). In proportion to the total number of specimens collected in each site,

Orders	F Value	P>F	Z	P>|Z|
Diptera	7.183	0.0011	8.6865	0.0130
Lepidoptera	23.558	0.0001	47.011	0.0001
Hymenoptera	20.152	0.0001	88.577	0.0001
Neuroptera	19.808	0.0001	37.980	0.0001
Megaloptera	3.265	0.0417	10.041	0.0066
Coleoptera	9.111	0.0002	37.095	0.0001
Hemiptera	29.231	0.0001	61.704	0.0001
Thysanoptera	25.192	0.0001	44.199	0.0001
Psocoptera	34.061	0.0001	80.214	0.0001
Dictyoptera	28.490	0.0001	40.006	0.0001
Dermaptera	1.000	0.3710	2.0000	0.3679
Orthoptera	3.639	0.0293	20.884	0.0001
Phasmida	3.743	0.0266	7.3392	0.0255
Embioptera	2.053	0.1330	4.0339	0.1331
Ephemeroptera	2.053	0.1330	4.0339	0.1331
Thysanura	7.384	0.0010	21.584	0.0001
Collembola	76.042	0.0001	87.335	0.0001
Araneae	44.493	0.0001	69.575	0.0001
Pseudoscorpionida	16.669	0.0001	41.737	0.0001
Acari	13.595	0.0001	22.399	0.0001
Chilopoda	1.022	0.3629	2.0517	0.3585
Amphipoda	1.000	0.3710	2.0000	0.3679
Isopoda	2.634	0.0760	5.4065	0.0670

Orders	F Value	P>F	Z	P>|Z|
Diptera	10.726	0.0016	-2.83456	0.0046
Lepidoptera	4.269	0.0421	1.96942	0.0489
Hymenoptera	17.918	0.0001	-6.37994	0.0001
Neuroptera	0.857	0.3576	0.270453	0.7868
Megaloptera	1.846	0.1781	-2.19185	0.0284
Coleoptera	12.988	0.0005	4.21338	0.0001
Hemiptera	7.535	0.0075	1.81420	0.0696
Thysanoptera	3.423	0.0681	-2.07431	0.0381
Psocoptera	1.775	0.1867	-1.54457	0.1225
Dictyoptera	15.591	0.0002	-2.63687	0.0084
Dermaptera				
Orthoptera	1.157	0.2853	0.280304	0.7792
Phasmida	4.944	0.0291	2.28269	0.0224
Embioptera	2.053	0.1559	-1.40546	0.1599
Ephemeroptera				
Thysanura	7.384	0.0081	3.34149	0.0008
Collembola	15.846	0.0002	5.15598	0.0001
Araneae	4.660	0.0340	1.61213	0.1069
Pseudoscorpionida	21.751	0.0001	6.16767	0.0001
Acari	19.898	0.0001	-3.97507	0.0001
Chilopoda	1.838	0.1791	1.40535	0.1599
Amphipoda				
Isopoda	4.944	0.0291	2.28269	0.0224

Table 3 a, b. Comparison of mean abundance of prevalent orders and classes.

a. Comparison for the 3 sites by Kruskal-Wallis. Test (Chi-Square Approximation, Df=2)

b. Comparison for the 2 sclerophyllous forests by Wilcoxon 2-Sample Test (Normal Approximation).

Psocoptera were abundant and Collembola were scarce in both sclerophyllous forests (fig. 1); whereas Diptera Nematocera and Acarina were more numerous while Hemiptera and Thysanoptera were relatively scarce in Rivière Bleue. The Païta site differed from the two others by high proportions of larvae (42% Lepidoptera, 42% Coleoptera, total 14% vs. c. 0%), and low proportion of adult Coleoptera (2.8% vs. c. 12%).

Theridiidae were the prevalent Araneae everywhere and were particularly abundant in the sclerophyllous forests (Table 4). In the Rivière Bleue rainforest, Clubionidae were almost as numerous as Theridiidae. Other important araneid families were Uloboridae in Païta, Philodromidae in Pindaï, Salticidae in Rivière Bleue. Among Coleoptera, Curculionidae were numerous everywhere. Other dominant groups were Ciidae and Cerambycidae in Païta, Phalacridae in Pindaï, Staphylinidae in Rivière Bleue. Cicadellidae were the prevalent Hemiptera in both sclerophyllous forests but not in Rivière Bleue. The dominant Heteroptera were Tingidae in Pindaï, Miridae in Rivière Bleue. Formicidae were the prevalent Hymenoptera in sclerophyllous forests even after exclusion of *W. auropunctata*. Other abundant groups were Braconidae in Païta and Encyrtidae in Pindaï. Chironomidae and Ceratopogonidae were the most numerous dipteran Nematocera everywhere. Cecidomyiidae and Sciaridae were also noticeably abundant in Païta and Rivière Bleue while a better balance between dipteran families was observed in Pindaï. In dipteran Brachycera, the relative abundance of Chloropidae was consistent in all sites. Muscidae were important only in Pindaï, Lauxaniidae only in Païta. Drosophilidae and Dolochopodidea were scarce in Pindaï.

The Païta sample lacked Pseudoscorpiones (present in Pindaï), Isopoda and Diplopoda. Thysanura were found only in Pindaï, Opiliones

Guilds	F Value	P > F	Z	P >I Z I
Chewers	9.774	0.0001	25.714	0.0001
Suckers	21.252	0.0001	47.083	0.0001
Scavengers	5.169	0.0071	14.494	0.0007
Ants	20.114	0.0001	84.423	0.0001
Parasitoids	16.467	0.0001	27.381	0.0001
Tourists	4.486	0.0133	5.8654	0.0533
Epiphyte grazers	6.186	0.0028	5.4969	0.0640
Insect predators	9.628	0.0001	13.655	0.0011
Other Predators	10.979	0.0001	19.150	0.0001
Uncertains	14.302	0.0001	34.563	0.0001

Guilds	F Value	P > F	Z	P >I Z I
Chewers	2.878	0.0938	1.59389	0.1110
Suckers	29.061	0.0001	4.53624	0.0001
Scavengers	5.994	0.0166	0.337116	0.7360
Ants	13.023	0.0005	5.62373	0.0001
Parasitoids	29.770	0.0001	4.55101	0.0001
Tourists	3.855	0.0532	-1.91552	0.0554
Epiphyte grazers	7.748	0.0067	1.47248	0.1409
Insect predators	5.378	0.0230	0.892044	0.3724
Other Predators	13.271	0.0005	2.95970	0.0031
Uncertains	16.755	0.0001	5.54159	0.0001

Table IV a,b. Comparison of mean abundance of trophic guilds.

a. Comparison for the 3 sites by Kruskal-Wallis Test (Chi-Square Approximation).

b.Comparison for Pindaï and Rivière Bleue forests by Wilcoxon 2-Sample Test (Normal Approximation).

(1 specimen) and Dermaptera only in Rivière Bleue. Each site lacked some families.

In proportion, ants were found more important in sclerophyllous forests, and constituted the dominant guild in Païta. Their abundance in Païta was so much greater that overall the abundances of the trophic guilds were found more similar between Rivière Bleue (rainforest) and Pindaï (sclerophyllous forest) than between the 2 sclerophyllous forests (Table IV). Without considering *W. auropunctata*, the 3 New Caledonian forests show similar proportions among the trophic guilds (Fig. 2). They are characterized by the prevalence of non-insect predators, mostly Araneae and epiphyte grazers. Tourists (mostly Diptera) were more abundant in Rivière Bleue forest than in sclerophyllous forests, but the difference between the 3 sites was not found significant when tested by Kruskall-Wallis test. The relative abundance of chewers and suckers is very low in the New Caledonian forests, especially in Rivière Bleue.

DISCUSSION

Implementation, Strengths & Weaknesses of the Method

The choice of fogging an area rather than a single species of tree was pragmatic: isolating a tree in New Caledonian forests implies extensive destruction. In addition, one may notice that in these forests the canopy of each tree is not spatially distinct, but rather is intimately intricated with the ones of surrounding trees; consequently, sampling an area rather than one tree may, in such forests, be representative of the ecological reality. Using many small standard collectors rather than a few large ones allows limited destruction of the lower vegetation and induces less disturbance in the biotop. Furthermore, it provides area-related data which allow analysis of spatial distribution and facilitate comparisons at various levels. As implemented here, fogging can be used by a reduced staff of 2 operators. Operators can sample from ground level, in vegetation up to 25 m in best weather conditions (still air, no rain). Small and fragile arthropods are collected in good condition for taxonomical studies. Good flyers (even of large body size: Macrolepidoptera, Cicadidae...) are sampled when fogging takes place at dawn before they can readily fly away.

In this implementation, the fogging method gives poor information on sampled vegetal volume and no information on faunal stratification. Sampling vegetation strates should be more informative that plain fogging, as a large proportion of the species which visit the canopy don't feed in it (Stork, 1991). Furthermore, the fogging method cannot be used by windy or rainy day. It is unable to sample arthropods which migrate from the ground to the canopy during the day, arthropods hidden under bark and most nocturnal arthropods. We also suppose that strong fliers would not be correctly sampled throughout the day.

Comparison of the Sites

Because *W. auropunctata* occurs in sclerophyllous forests, Rivière Bleue forest has the lowest total numbers of specimens /m^2. It differs also from both sclerophyllous forests by higher relative abundance of Collembola, Acarina, Appendix. Relative abundance of taxa (% of ind. in prevalent orders).

	Païta	Pindaï	RBleue
Araneae			
Araneidae	6.7	3.2	3.6
Clubionidae	13.8	25.0	30.6
Gnaphosidae	2.1	0.3	0.0
Linyphidae	0.5	0.2	6.8
Oonopidae	3.8	3.9	8.3
Philodromiidae	0.4	13.2	0.0
Salticidae	1.3	2.2	12.5
Tetragnathidae	1.2	0.4	0.5
Theridiidae	56.7	47.3	32.2
Thomisidae	1.2	2.7	1.8
Uloboridae	12.4	0.3	1.0
Others	0.1	1.4	2.6
	100	100	100
Coleoptera			
Aderidae	2.3	0.0	2.4
Anthribidae	2.3	2.4	0.8
Attelabidae	0.0	4.7	0.0
Byrrhidae	4.8	0.0	3.8
Cebrionidae	0.0	1.2	0.0
Cerambycidae	14.9	4.7	0.8
Chrysomelidae	2.7	7.4	4.3
Ciidae	27.1	1.6	1.0
Coccinellidae	7.8	8.9	3.8
Colydiidae	0.8	0.6	1.5
Corylophidae	0.6	7.2	5.0
Cryptophagidae	0.0	3.1	1.9
Cucujidae	1.8	0.6	2.0
Curculionidae	21.0	16.5	32.5
Lathrididae	2.7	5.6	1.1
Melandryidae	0.0	0.0	2.4
Merophysiidae	0.2	0.0	4.6
Nitidulidae	0.3	6.4	0.0
Phalacridae	0.0	20.9	0.7
Pselaphidae	1.6	0.6	7.9
Scolytidae	2.1	4.0	4.2
Staphylinidae	4.2	2.0	17.5
Others	2.7	1.4	1.8
	100	100	100
Hemiptera			
Aleyrodidae	1.0	0.5	2.5
Anthocoridae	0.8	2.9	3.1
Aphididae	3.4	0.0	0.3
Aradidae	3.4	1.1	3.1
Cicadellidae	40.4	40.6	8.1

	Païta	Pindaï	RBleue
Delphacidae	8.6	3.3	4.5
Fulgoridae	0.0	1.6	6.4
Lygaeidae	4.4	0.8	2.5
Margarodidae	0.7	0.7	0.0
Miridae	1.6	2.7	11.7
Pentatomidae	0.4	1.2	0.0
Psyllidae	1.3	13.1	13.1
Reduviidae	4.3	1.5	1.4
Tingidae	2.4	11.9	10.1
Homoptera larvae	17.4	2.9	7.3
Heteroptera larvae	6.8	14.3	13.1
Others	3.2	1.1	12.8
	100	100	100
Diptera			
Nematocera			
Cecidomyiidae	14.6	6.2	17.4
Ceratopogonidae	36.9	30.7	36.9
Chironomidae	25.5	48.7	30.8
Mycetophilidae	0.9	1.1	0.2
Psychodidae	5.5	0.3	0.9
Sciaridae	16.0	7.6	11.8
Tipulidae	0.6	5.1	1.5
Others	0.0	0.2	0.5
	100	100	100
Brachycera			
Chloropidae	33.0	37.2	44.0
Dolichopodidae	10.8	2.1	7.3
Drosophilidae	13.6	1.3	13.6
Empididae	0.2	5.0	13.9
Lauxaniidae	22.8	8.4	9.7
Milichiidae	0.2	0.4	3.1
Muscidae	7.0	15.9	1.6
Phoridae	6.1	6.3	1.0
Sarcophagidae	0.9	4.2	0.0
Tachinidae	1.9	4.6	0.3
Tephritidae	1.0	8.4	1.8
Others	2.6	6.3	3.7
	100	100	100
Hymenoptera (excl. *W. auropunctata*)			
Agaonidae	6.6	0.0	0.1
Aphelinidae	11.9	9.2	22.0
Braconidae	16.4	4.0	7.5
Ceraphronidae	1.4	0.7	1.5
Cleptidae	0.8	1.7	1.2
Encyrtidae	7.4	17.5	7.6
Eulophidae	13.6	5.5	11.2
Eupelmidae	1.2	0.6	0.0

Appendix (continued)

	Païta	Pindaï	RBleue
Hymenoptera (excl. *W. auropunctata*)			
Formicidae	18.2	23.5	19.5
Ichneumonidae	1.9	1.2	0.8
Mymaridae	5.5	8.7	6.4
Platygasteridae	6.9	3.4	11.1
Pteromalidae	1.1	4.7	3.0
Scelionidae	4.8	10.9	5.0
Sphecidae	0.0	4.3	0.0
Torymidae	0.6	0.8	0.4
Trichogrammatidae	0.6	2.2	0.7
Others	1.3	1.0	1.9
	100	100	100

Nematocera, Aphelinidae, Tingidae, Curculionidae, Staphylinidae and by relative scarcity of Araneae, Psocoptera, Thysanoptera and Hemiptera, especially Cicadellidae. The prevalence of Chironomidae and Ceratopogonidae in Rivière Bleue might be related to the vicinity of the river banks, but the absence of permanent streams excludes such explanation in Païta and in Pindaï sclerophyllous forests. Aggregative patterns seem more common in sclerophyllous forests, which could be attributed to greater physical heterogeneity of the canopy. In spite of their overall similarity, sclerophyllous forests display some differences: some may be explained by floristic composition (Agaonidae which are related to presence of *Ficus* in Païta; Jaffré & Veillon, pers. comm.) or by microclimatic conditions (fungal eaters Lauxaniidae are less abundant in the drier forest of Pindaï). Selective predation may also be involved. Further analysis is required to verify the persistence of such differences and similarities throughout the year.

Ants are generally abundant in tropical canopies, which is the case only in our samples from sclerophyllous forests (Païta in particular) (Fig. 2), seemingly owing to the introduction of *Wasmannia auropunctata*. The dominance of these introduced ants in Païta is associated with scarcity of epiphyte grazers (Table 4), as observed by Grant & Moran (1986) from their South African samples. The scarcity of non-introduced ants resembles the pattern observed in *Argyrodendron* canopy in Queensland (Basset & Arthington, 1992). This scarcity has been hypothetized to be the result of a lesser productivity (Majer, 1990). Here dry season water stress could explain the difference between Pindaï (dryer) and Païta (wetter). However, such an explanation cannot be applied to the pattern observed in the evergreen forest of Rivière Bleue.

Prevalence of non-insect predators, mostly Araneae and epiphyte grazers as observed in the three New Caledonian forests, is characteristic of temperate forests rather than of tropical ones (Basset & Arthington, 1992). The high proportion of 'tourists' observed in Rivière Bleue forest could be due to the higher rainfall and the vicinity of the river banks.

More differences should obviously be observed between sites at genus and species level. For example, Coccinellidae are represented by 9 genera and 12 species in Païta, 8 species and 7 genera in Pindaï, 4 genera and 5 species in Rivière Bleue. Païta and Pindaï have 2 genera and 2 species in common: 1 species is endemic, the other was introduced recently.

When compared with results obtained in Queensland (Kitching et al., 1993), the Rivière Bleue sample is found quite similar to tropical samples from the 'Green Mountains' (Kitching et al., 1993); differences are found principally in the proportions of Collembola and Acari. The two New Caledonian sclerophyllous forests samples are more similar to the subtropical samples from the 'Green Mountains', except for the relative abundance of Collembola which is weaker in New Caledonian samples.

ANTHROPIC AGGRESSION & INVASION OF BIOTAS

W. auropunctata has been recorded in New Caledonia since 1972 (Fabres & Brown, 1978). Its introduction and the rapid invasion of coastal lowlands is attributed to human activity. Open areas and bush fires benefit the invader. Relictual forests like Païta (surrounded by pastures and *Melaleuca* savanas) and Pindaï (surrounded by frequently burnt *Acacia spirorbis* woodlands) are more exposed to invasion. The relative isolation of the dense evergreen forest, as well as its ecological characteristics, may have prevented or delayed the arrival of the ant.

At this stage we cannot ascertain the reason for depletion in specific richness in the invaded forests. Interference competition of *W. auropunctata* may have displaced other ants and spiders as observed elsewhere (Pollard & Persad, 1991). Hence important changes in faunal equilibrium may be expected in invaded areas. Subsequent sampling will refine that point.

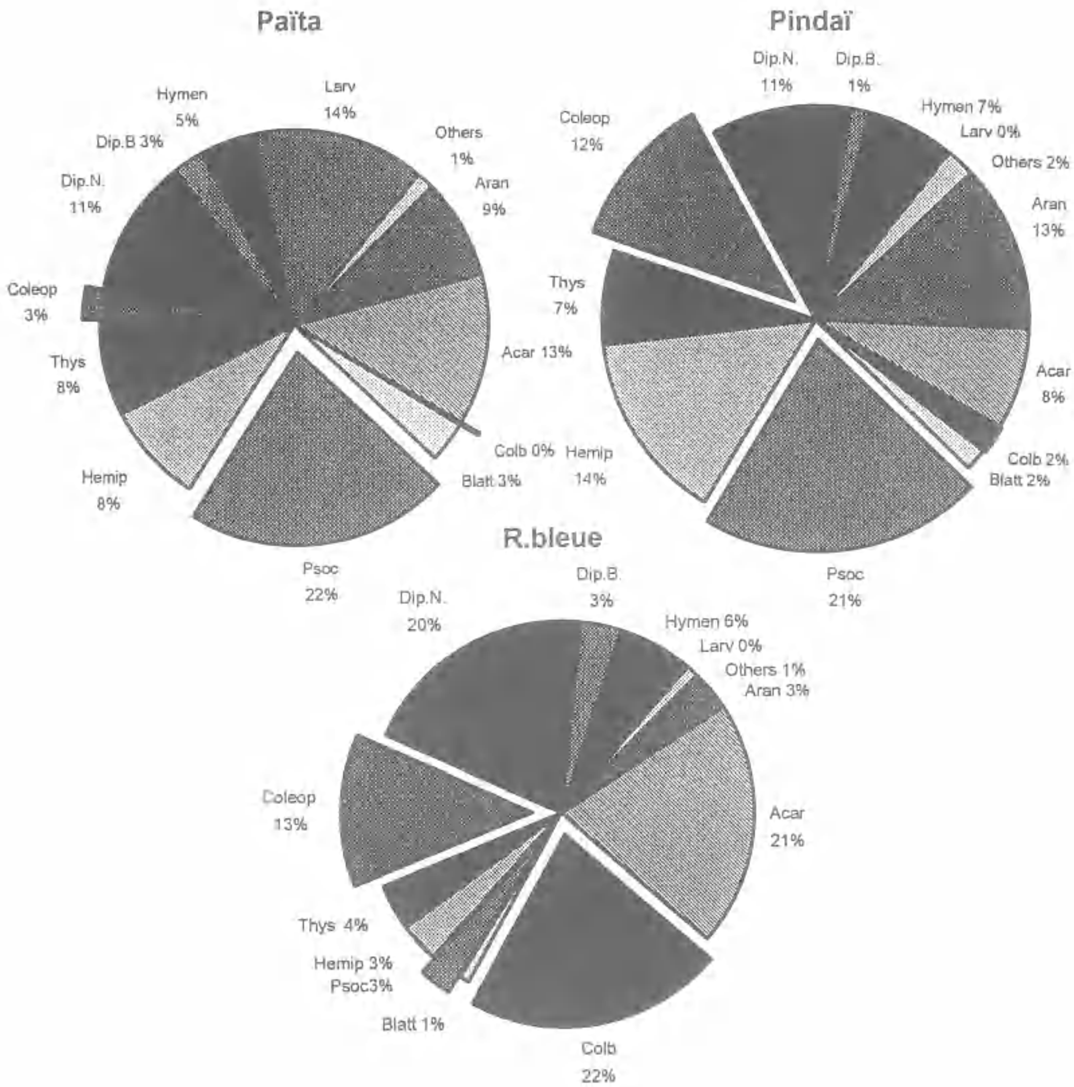

Fig. 1. Relative abundance of prevalent groups. Aran., Araneae; Acar., Acarina; Colb., Collembola; Blatt., Battodea; Psoc., Psocoptera; Hemip., Hemiptera; Thys., Thysanoptera; Coleop., Coleoptera; Dip.N., Diptera Nematocera; Dip.B., Diptera Brachycera; Hymen., Hymenoptera (excluding *W. auropunctata*); Larv., Insect larvae.

CONCLUSION

Sorting to family level a single sample of each of our sites allowed distinction between the sites, and indicates that probably larger New Caledonian forest types may be characterized usng this technique. However, understanding diversity requires more than defining the taxonomic structure of communities at one time. Seasonal changes may affect the proportions of the different taxa, including the presence or absence of some of them. The use of small standard collecting units throughout one year should allow analysis of the distribution of taxa through time and space, and will provide a test for the efficiency of the method: have we undersampled the area? Is our sample 'representative' of the biotope? Another question is the taxonomic level of the analysis – family level allows rapid results, but is obviously far less precise than specific level. How is the relationship between these two levels in terms of diversity and of community

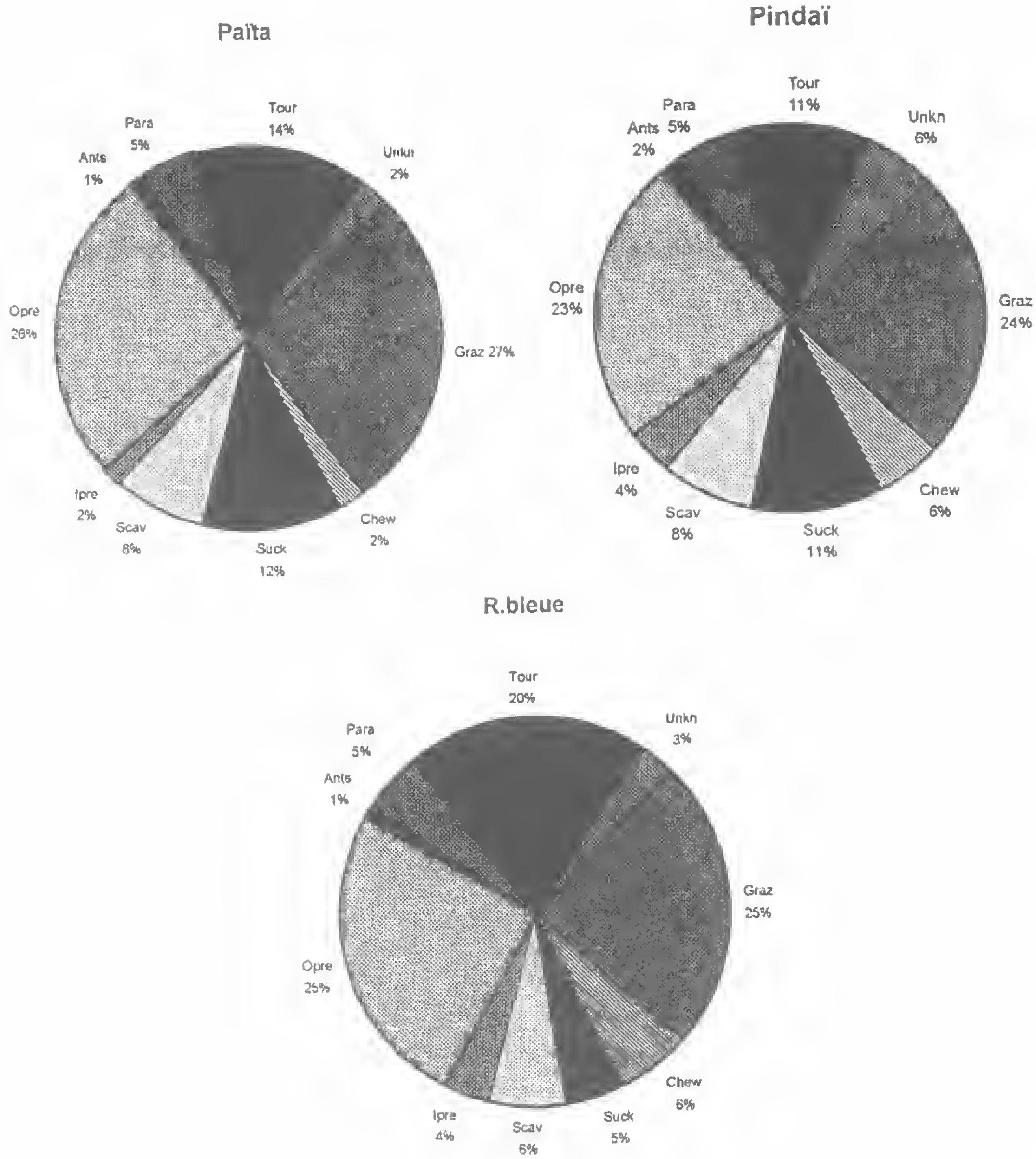

Fig 2. Relative abundance of trophic guilds. Abbreviations: Graz, Epiphyte grazers; Chew, Chewers; Suck, Suckers; Scav, Scavengers; Ipre, Insect predators; Opre, Other predators; Ants, Ants (excluding *W. auropunctata*); Para, Parasitoids; Tour, Tourists; Unkn, Unknown.

structure? Does one level show more spatial and temporal stability than the other?

For ecological analysis, clearly the use of other methods of sampling and life history studies should complement fogging. The scientific value of data on identified host plants, related faunas and their stratification is beyond all question. Although the fogging method is relatively weighty, it constitutes a fast global approach of biota which might provide the information we most urgently need to promote conservation of ecologically sensitive forested areas.

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LITERATURE CITED

BASSET, Y. 1991. The taxonomic composition of the arthropod fauna associated with an Australian rainforest tree. Australian Journal of Zoology 39: 171-190.

BASSET, Y. & ARTHINGTON, A.H. 1992. The arthropod community of an Australian rainforest tree : abundance of component taxa, species richness and guild structure. Australian Journal of Ecology 17: 89-98.

BONNET DE LARBOGNE, L., CHAZEAU, J., TILLIER, A. & TILLIER, S. 1991. Milieux naturels néo- calédoniens : la Réserve de la Rivière Bleue. Mémoires du Muséum national d'Histoire naturelle (Zoologie) 149: 9-17.

CANCELA DA FONSECA, J.P. 1966. L'outil statistique en biologie du sol III. Indices d'intérêt écologique. Revue d'Ecologie et de Biologie du Sol 3: 381-407.

CHAZEAU, J. & TILLIER S. 1991. Zoologia Neocaledonica, 2. Memoires du Museum National d'Histoire Natuelle, Série A (Zoologie), 149. Pp. 358.

ERWIN, T.L. 1982. Tropical forests: Their richness in Coleoptera and other species. Coleopterists Bulletin 36: 74-75.

1983. Beetles and other insects of tropical forest canopies at Manaus, Brazil, sampled by insecticidal fogging. Pp. 59 - 79. In Sutton, S.L. & al. (eds), 'Tropical rainforest ecology and management'. (Blackwell : Oxford).

FABRES, G. & BROWN, W.L. 1978. The recent introduction of the pest ant *Wasmannia auropunctata* into New Caledonia. Journal of the Australian entomological Society 17: 139-142.

GRANT S. & MORAN, V.C. 1986. The effects of forraging ants on arboreal insect herbivores in an undisturbed woodland savanna. Ecological Entomology 11: 83-93.

JAFFRÉ, T., MORAT, P. & VEILLON, J.-M. 1993. Etude floristique et phytogéographique de la forêt sclérophylle de Nouvelle-Calédonie. La forêt sclérophylle de la Province Sud de la Nouvelle-Calédonie. Adansonia 15 (1-4): 107-146.

JAFFRÉ, T. & VEILLON, J.-M. 1991. Etude floristique et structurale de deux forêts dense humides sur roches ultrabasiques en Nouvelle-Calédonie. Adansonia 12 (3-4): 243-273.

KITCHING, R.L., BERGELSON, L.M., LOWMAN, M.D., MCINTYRE, S. & CARRUTHERS, G. 1993. The biodiversity of arthropods from Australian rainforest canopies: general introduction, methods, sites and ordinal results. Australian Journal of Ecology 18: 181-191.

MAJER, J.D. 1990. The abundance and diversity of aboreal ants in northern Australia. Biotropica 22: 191-199.

MARTIN, J.L. 1966. The insect ecology of red pine plantations in central Ontario. IV. The crown fauna. Canadian Entomologist 98:10- 27.

MATILE, L., NAJT J. & S. TILLIER (eds.) 1993. Zoologia Neocaledonica, 3. Memoires du Museum National d'Histoire Natuelle, Série A (Zoologie), 157. Pp. 218.

MAY, R.M. 1990. How many species? Philosophical Transactions of the Royal Society of London 330: 293-304.

MORAN, V.C. & SOUTHWOOD, T.R.E. 1982. The guild composition of arthropod communities in trees. Journal of Animal Ecology 51: 289-306.

MYERS, N. 1988. Threatened biotas: "hot spots" in tropical forests. The environmentalist 8 (3): 187-208.

POLLARD, G.V. & PERSAD, A.B. 1991. Some ant predators of insect pests of tree crops in the Caribbean with particular reference to the interaction of *Wasmannia auropunctata* and the leucaena psyllid *Heteropsylla cubana*. Pp. 392-403. In 'Rencontres Caraïbes en Lutte biologique', INRA, Paris, Les Colloques, 58.

ROBERTS, H.F. 1973. Arboreal Orthoptera in the rain forest of Costa Rica collected with insecticide: a report of the grasshoppers (Acrididae) including new species. Proceedings of the Academy of Natural Science of Philadelphia 125: 46-66.

STORK, N.E. 1987. Guild structure of arthropods from Bornean rain forest trees. Ecological Entomology 12: 69-80.

1988. Insect diversity: facts, fiction and speculation. Biological Journal of the Linnaean Society 35: 321-337.

1991. The composition of the arthropod fauna of Bornean lowland forest trees. Journal of tropical Ecology 7: 161-180.

TILLIER, S. 1988. Zoologia Neocaledonica, 1. Memoires du Museum National d'Histoire Naturelle, Série A (Zoologie), 142. Pp. 158.